Measurement of Plume Growth Rate From Satellite Imagery for ESP Estimation

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The eruption of Eyjafjallajokull, Iceland in April and May, 2010, brought to light not only the hazards of airborne volcanic ash but also the importance of Volcanic Ash Transport and Dispersion models (VATD) to estimate the concentration of ash with time. These models require Eruption Source Parameters (ESP) as input, which typically include information about the plume height, the mass eruption rate, the duration of the eruption and the particle size distribution. However much of the time these ESP are unknown or poorly known a priori.

Using satellite images, we show that the mass eruption rate can be estimated from the downwind plume or umbrella cloud growth rate. A simple version of the continuity equation can be applied to the growth of either an umbrella cloud or the downwind plume. The continuity equation coupled with the momentum equation using only inertial and gravitational terms provides another model. Numerical modeling or scaling relationships can be used, as necessary, to provide values for unknown or unavailable parameters. Use of these models applied to data on plume geometry provided by satellite imagery allows for direct estimation of plume volumetric and mass growth with time.

This methodology was tested by comparing our results with five well-studied and well-characterized historical eruptions: Mount St. Helens, 1980; Pinatubo, 1991, Redoubt, 1990; Hekla, 2000 and Eyjafjallajokull, 2010. The methodologies yield results comparable to or better than currently accepted methodologies of ESP estimation. We then applied the methodology to umbrella clouds produced by the eruptions of Okmok, 12 July 2008, and Sarychev Peak, 12 June 2009, and to the downwind plume produced by the eruptions of Hekla, 2000; Kliuchevsko'i, 1 October 1994; Kasatochi 7-8 August 2008 and Bezymianny, 1 September 2012.

The new methods allow a fast, remote assessment of the mass eruption rate, even for remote volcanoes. They thus provide an additional path to estimation of the ESP and the forecasting of ash cloud propagation.